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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No.: 09/900,881 Group No.: 1724

Inventors: Bikson et al. Filed: July 10, 2001

Title: INTERNAL HOLLOW FIBER MEMBRANE GAS DRYER AND FILTRATION DEVICE Examiner: Spitzer

AMENDMENT

Mail Stop Non-Fee Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is in response to the Office Action of April 9, 2003. A Three month extension of time is attached hereto in duplicate.

1. (Twice Amended) A gas purification process comprising:

a) passing a feed gas stream containing water vapor through at least one filtration element ~~adopted~~ adapted to suspend matter from said incoming feed gas passing therethrough to produce a filtered feed gas,

b) contacting the filtered feed gas with a multiplicity of hollow fiber membranes contained in a cartridge, permeating a portion of the water vapor contained in the feed gas stream through the membranes, and

c) recovering the main remaining nonpermeate dehydrated and filtered gas stream wherein said filtration element and said hollow fiber membrane cartridge are disposed around a common longitudinal axis and are enclosed in a common casing.

2. (Original) The gas purification process of claim 1 wherein said filtration element at least partially surrounds said membrane cartridge.

3. (Original) The gas purification process of claim 1 wherein said membrane cartridge at least partially surrounds said filtration element.

4. (Original) The gas purification process of claim 1 wherein said filtration element is positioned below said hollow fiber membrane cartridge.

5. (Original) The gas purification process of claim 1 wherein said membrane cartridge is encased with a nonpermeable film barrier except for a non-encased circumferential region adjacent to one end of said membrane cartridge.

6. (Once Amended) The gas purification process of claim 1, wherein said process further includes, ~~between~~ in steps (c), ~~and (d)~~ utilizing a portion of a resultant nonpermeate dehydrated gas stream internally of the cartridge to provide a sweep gas to the permeate side of the hollow fiber membranes substantially countercurrent to the flow of the feed gas stream.

7. (Original) The gas purification process of claim 6 wherein the sweep gas flow rate is from 5% to about 30% of the net flow rate of the nonpermeate dehydrated and filtered gas.

8. (Original) The gas purification process according to claim 1 wherein the feed gas is comprised of compressed air.

9. (Original) The gas purification process of claim 1 wherein the feed gas stream is introduced to the exterior of the hollow fiber membranes at a first end of the hollow fiber membrane cartridge and the dehydrated nonpermeate gas is removed from the exterior of the hollow fiber membrane at a second end of the hollow fiber membrane cartridge.

10. (Original) The gas purification process of claim 6 wherein the sweep gas flow is controlled by an orifice that allows for a predetermined amount of the nonpermeated dehydrated gas to pass to the permeate side of the hollow fiber membrane.

11. (Original) The gas purification process of claim 10 wherein said orifice is removably attached to said cartridge.

12. (Previously amended) The gas purification process of claim 1 further comprising a cyclone separator disposed in front of the filtration element.

13. (Original) The gas purification process of claim 1 wherein said filtration element and said hollow fiber membrane cartridge are placed in a sealed and removable manner inside said casing.

14. (Original) The gas purification process of claim 13 wherein said filtration element abuts the hollow fiber membrane cartridge.

15. (Original) The gas purification process of claim 14 wherein said filtration element is removably attached to said hollow fiber membrane cartridge.

16. (Original) The gas purification process of claim 1 wherein said filtration element is a coalescing filter.

17. (Original) The process of claim 1 wherein the packing density of the hollow fibers in said cartridge is varied along the axial length of the cartridge.

18. The process of claim 1 wherein in step (c) a portion of at least one additional gas contained in said feed gas is permeated through the membranes.

19. (Original) The process of claim 1 wherein said cartridge includes:

a) an elongated tubular inner core member,

b) a substantially cylindrical hollow fiber membrane bundle surrounding said inner core member constructed from hollow fiber membranes having permeate and nonpermeate sides, said bundle being characterized as having a substantially countercurrent flow arrangement between the gas flow on said permeate side and the gas flow on said nonpermeate side,

c) two tubular tubesheets encapsulating both ends of said hollow fiber bundle in a fluid-tight arrangement with one end of the inner core

member opening out of one of said tubesheets to permit the flow of gas in and out of said inner core member, and wherein at least one of said tubesheets is severed to permit flow of gas in and out of the hollow fiber lumens,

d) a shell and at least one end closure surrounding said hollow fiber membrane bundle,

e) a flow-control orifice that directs a predetermined amount of nonpermeate gas as a sweep into the permeate side of the hollow fiber membranes.

20. (Original) The process of claim 19 wherein said hollow fiber membranes are wound around said tubular core member.

21. (Previously amended) gas purification process comprising:

a) contacting a feed gas with a multiplicity of hollow fiber membranes contained in a cartridge,

b) permeating a portion of water vapor contained in the feed gas stream through the membranes while simultaneously removing suspended matter contained in said feed gas, and

c) recovering the main remaining nonpermeate dehydrated and filtered gas stream.

22. (Original) The gas purification process of claim 21 wherein said membrane cartridge is encased with a nonpermeable film barrier except for a non-encased circumferential region adjacent to one end of said membrane cartridge.

23. (Original) The gas purification process of claim 21, wherein said process further includes utilizing a portion of a resultant nonpermeate dehydrated gas stream internally of the cartridge to provide a sweep gas to the permeate side of the hollow fiber membranes substantially countercurrent to the flow of the feed gas stream.

24. (Original) The gas purification process of claim 23 wherein the sweep gas flow rate is from 5% to about 30% of the net flow rate of the nonpermeate dehydrated gas.

25. (Original) The gas purification process of claim 21 wherein the feed gas is comprised of compressed air.

26. (Original) The gas purification process of claim 21 wherein the feed gas stream is introduced to the exterior of the hollow fibers at a first end of the hollow fiber membrane cartridge and the dehydrated nonpermeate gas is removed from the exterior of the hollow fibers at a second end of the hollow fiber membrane cartridge.

27. (Original) The process of claim 21 wherein said hollow fiber membranes are wound around a central core member.

28. (Previously amended) A gas purification apparatus comprising:

a) a housing body defined by a first and second essentially cylindrical shells connected in a sealed and removable manner in correspondence with their axial end portion to a head closure member interposed therebetween, said first and second shells defining a lower internal chamber and upper internal chamber within said housing, wherein said head closure member having formed therethrough a feed gas inlet port in a first end of said head closure member and an outlet port in a second end of said head closure member, and at least one gas transfer conduit in fluid communication with said upper and lower internal chambers,

b) a gas filtration element adapted to separate suspended matter from incoming gas passing therethrough disposed in said lower chamber and,

c) a hollow fiber membrane cartridge adopted to separate water vapor from incoming gas passing therethrough disposed in said upper chamber wherein said filtration element and said hollow fiber membrane cartridge are disposed around a common longitudinal axis within said housing body, said axis being essentially concentric to said housing body.

29. (Original) The apparatus of claim 28 wherein said cartridge comprises:

a) an elongated tubular inner core member,

b) a substantially cylindrical hollow fiber membrane bundle surrounding said inner core member constructed from the hollow fiber membranes having permeate and nonpermeate sides, said bundle being characterized as having a substantially countercurrent flow arrangement between the gas flow on said permeate side and the gas flow on said nonpermeate side,

c) two tubular tubesheets encapsulating both ends of said hollow fiber bundle in a fluid-tight arrangement with one end of the inner core member opening out of one of said tubesheets to permit the flow of gas in and out of said inner core member and wherein at least one of said tubesheets is severed to permit an unobstructed flow of gas in and out of the hollow fiber lumens.

30. (Original) The apparatus of claim 29 wherein said cartridge further contains an orifice that allows for a predetermined amount of the nonpermeate gas to pass to the permeate side of the hollow fiber membranes as a sweep.

31. (Original) The apparatus of claim 29 wherein said membrane cartridge is encased with a nonpermeable film barrier essentially along the entire length of the multiplicity of hollow fiber membranes except for a non-encased circumferential region adjacent to one end of said membrane cartridge.

32. (Original) The apparatus of claim 28 wherein the feed gas stream is introduced to the exterior of the hollow fiber membranes at a first end of the hollow fiber membrane cartridge and the dehydrated nonpermeate gas is removed from the exterior of the hollow fiber membranes at a second end of the hollow fiber membrane cartridge.

33. (Original) The apparatus of claim 29 wherein said hollow fiber membranes are wound around said tubular core member.